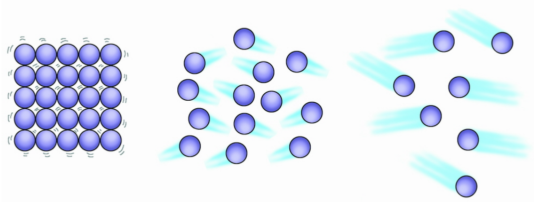
Thermal physics



Dust particles do not settle as air molecules hit dust particles continuously and unevenly. The hits cause movement in all directions. Even hits by small molecules can move a large particle. Air molecules are fast moving / have high energy.

When a liquid has a high temperature, it has high kinetic energy. Higher energy molecules have a greater chance to escape the surface of a liquid. This is because higher energy molecules have energy to break bonds / separate liquid molecules / overcome forces. The energy is used as work for this and it is known as **evaporation**. As the high energy molecules move out of the liquid, it consequently cools down.

To increase the rate of evaporation, increase the surface area from which the molecules are moving out of or blow air over the surface. Increase the temperature and reduce the humidity.

The difference between evaporation and boiling of water is that boiling happen throughout the liquid but evaporation only at the surface. The liquid bubbles in boiling, but not in evaporation. You can evaporate a liquid at any temperature but you can only boil it at its boiling point.

In the **thermal expansion** of a solid, higher temperature means higher energy/greater speed of molecules/particles. The vibrations get bigger or movement greater/take up more space. In the thermal expansion of a gas, the speed/energy of molecules is greater hence the separation of molecules greater. The molecules take up more space or increased pressure causes container to get bigger. (liquid?)

The expansion of liquids compared to solids, for the same temperature rise, is slightly more. In gases it is much more. Basically, water and liquids expand more than solids. The property of expansion is used in thermometers.

$$P_1V_1 = P_2V_2$$

This law only applies if the gas is kept at a constant temperature. If a gas is kept in the same volume but the temperature is increased, pressure will increase. If a gas is kept at constant pressure but the temperature is increased, volume will increase.

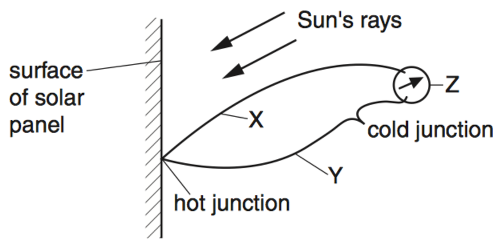
Alcohol is often used to **measure temperature** because it has regular/uniform expansion, it expands a lot/large expansivity, it is non-toxic, has low freezing point, high melting point and it measures low temperatures.

Fixed points are two standard temperatures which must be chosen against which others can be judged. They need to be defined so that they can be reproduced in labs anywhere in the world. For example, on the Celsius scale, 0 degrees is the lower fixed point where ice melts. 100 degrees i the upper fixed point where water boils.

(look in the book p103 for liquid-in-glass thermometers)

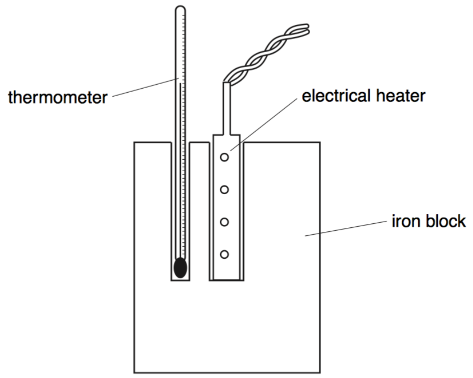
High **sensitivity** is when there is a large expansion/change in reading for small change in temperature. A **linear scale** is when the distance between each degree on a scale is the same.

To give a thermometer a greater range, you make the capillary tube longer or fill it with a liquid with a lower expansivity. To make a thermometer more sensitive, you make the capillary tube thinner or fill it with a liquid with higher expansivity or make a bigger bulb.



A thermocouple thermometer has 2 junctions at different temperatures, one is hot and the other one is cold. Temperature difference causes e.m.f./voltage/ current to pass and hence the reading of the meter changes (with temperature). 1 junction is at a known temperature as it is needed for calibration.

If X is of copper wire, then Y is of a different metal. Z is a galvanometer.



Thermal capacity is the heat/energy required to change the temperature of a body by 1 °C. A rise in the temp of a body provides an increase in internal energy.

Mass x specific heat capacity = thermal capacity

energy transferred = mass x specific heat capacity x temp. change

To measure the specific heat capacity of a substance eg. iron, you could take of block of it and place an electrical heater and thermometer within it. To find the specific heat capacity, you must measure the starting temperature and final temperature (or change in temperature), the mass of iron, power of the heater and the time when the heater is turned on.

The value obtained with this apparatus is higher than the actual value, because heat is lost to surroundings/air. To improve the accuracy of the experiment, one could add lagging or insulate.

When melting or boiling a substance, energy is put in, but there is no change in temperature. The energy absorbed is called the **latent heat of fusion/vaporisation**. A change of state happens when the particles have enough energy to overcome the forces between them. In melting, the solid vibrates so much that the particles can break away from their positions.

The latent heat of fusion is the amount of energy needed to melt 1Kg of a substance. The latent heat of vaporisation is the amount of energy needed to boil 1Kg of a substance. When a substance freezes it is losing the same amount of energy as the latent heat of fusion.

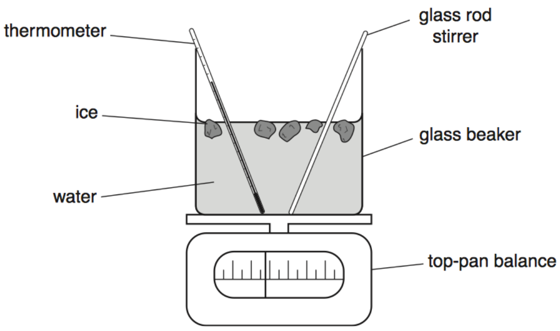
When a liquid below its boiling point changes into a gas, this is known as **evaporation**. When a gas changes back to a liquid, this is called **condensation**. When a liquid turns into a solid, this is called **solidification**.

- Use the terms latent heat of vaporisation and latent heat of fusion and give a molecular interpretation of latent heat

Latent heat is the energy required to change state with no change in temperature OR energy to break bonds between molecules with no change in K.E.

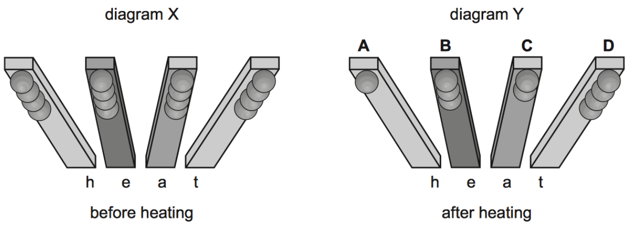
eg. The specific latent heat of vaporisation of water is 2260kJ/kg. Explain why this energy is needed to boil water and why the temperature of the water does not change during the boiling.

energy/work to separate molecules (against) forces of attraction between water molecules
The k.e./speed of the molecules does not increase
energy transferred = mass x specific latent heat



To measure the specific latent heat for ice, the student has added ice at 0 °C to water at 20 °C. The water is stirred continuously as ice is slowly added until the temperature of the water is 0 °C and all the added ice has melted. Three mass readings have to be taken - the mass of the beaker + stirrer + thermometer, the total mass before ice is added and the total mass after ice has melted.

When a material is heated, the particles move fast, push on neighbouring particles and speed those up too. In metals, energy is also transferred by free electrons. They also speed up when the metal is heated, and they collide with atoms causing them to vibrate faster. Hence metals are good conductors of conduction.

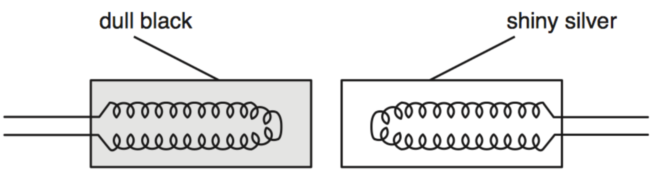


An experiment is set up to find out which metal is the best **conductor** of heat. Balls are stuck with wax to rods made from different metals, as shown in diagram X. The rods are heated at one end. Some of the balls fall off, leaving some as shown in diagram Y. The best conductor of heat is A, as most of the balls have fallen off.

More thermal energy can be transferred if..

- the temp. difference between the ends of the bar is increased
- the cross sectional area of the bar is increased
- the length of the bar is reduced

As a fluid (liquid or gas) warms up, the particles which are warmer become less dense and rise. They then cool and fall back to the heat source, creating a cycle called a **convection current**. As particles circulate they transfer energy to other particles. If a cooling object is above a fluid it will create a convection current (like the freezing compartment at the top of a fridge)



Infra-red radiation is part of the electromagnetic spectrum. It is also another name for heat radiation. The picture shows two metal plates, of which one's front surface is dull black and other one's front surface is shiny silver. To test which one is the best **emitter**, we can take a thermocouple thermometer. To ensure fair comparison, the distance between the plate and the thermometer should be the same for both. The dull black is a better radiator, meaning it emits more heat/radiation than the shiny silver.

To test for good and bad **absorbers** of infra-red radiation, one can take two containers, which are identical, and painted on the outside. One is dull black, the other is shiny white. Both are filled with water, initially at the same temperature. They will be heated for the same time and the temperatures can then be taken. The dull black box will have a higher temperature than the shiny white box. High sensitivity will be important in this experiment because the temperature change is very small.